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Application number GB **0803959.6**

1. Your reference: P105168.GB.01/NHE
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2. Full name, address and postcode of the applicant or of each applicant *(underline all surnames)*:
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Patents ADP number *(if you know it)*: 08333072003

3. Title of the invention: An Improved Mist Generating Apparatus

4. Name of your agent *(if you have one)*: Murgitroyd & Company

"Address for service" to which all correspondence should be sent. This may be in the European Economic area or Channel Islands (see warning note below) *(including the postcode)*:
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Patents ADP number *(if you know it)*: 1198015

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(REV DEC07)

AN IMPROVED MIST-GENERATING APPARATUS

The present invention is directed to an apparatus suitable for generating a mist. More particularly, the invention is directed to an improved mist-generating apparatus which generates a mist through the interaction of two fluids. The present invention is intended for use in a wide variety of applications. However, two applications to which the invention is particularly suited are fire suppression and decontamination.

WO01/76764 shows a mist generating apparatus which uses two fluids, primarily for use in fire suppression. In WO'764 a spray of first fluid droplets is created by forcing the first fluid through a number of aerosol nozzles in a conventional manner. The droplets are then carried by a stream of a second fluid through a convergent-divergent nozzle which sprays the combined stream of first fluid droplets and second fluid from the apparatus. The purpose of WO '764 is to reduce the pressure required to create the aerosol spray of the first fluid by using the second stream of fluid to carry the first fluid droplets out of the apparatus. The second stream also reduces frictional forces which can in some cases cause the first fluid droplets forming the aerosol spray to evaporate.

WO '764 does not use the second fluid in order to create the first fluid droplet regime. Instead, the droplets are created via an array of aerosol nozzles which create the droplets in a conventional manner. The stream of second fluid then carries the droplets through the spray nozzle without any atomisation mechanism being applied to the first fluid by the second fluid. Thus, WO' 764 still requires the first fluid to be supplied at relatively high pressure in order to create the aerosol droplets.

WO2005/082545 and WO2005/082546 to the same applicant as the present application addressed the deficiencies in prior art arrangements such as WO '764 by using a high velocity stream of a second fluid (e.g. steam) to impart a shear force on a first fluid to create a mist of first fluid droplets. The geometric arrangement of the first and second fluid passages in the apparatus shown in WO'545 and WO'546 allowed the mist to be generated using first and second fluids which were supplied at relatively low pressure compared to arrangements such as that shown in WO'764.

Whilst WO'545 and WO'546 disclose mist generating apparatus which have a number of benefits and improvements over the prior art, the applicant has now developed a further improved mist generating apparatus which provides additional benefits to the performance and construction of these mist generating apparatus.

According to a first aspect of the present invention, there is provided a mist generating apparatus comprising:

a first fluid passage having a first fluid inlet and a first fluid outlet;

a first fluid supply channel having a first end adapted to be connected to a supply of a first fluid and a second end connected to the first fluid inlet;

a second fluid passage having a second fluid inlet and a second fluid outlet; and

a second fluid supply channel having a first end adapted to be connected to a supply of a second fluid and a second end connected to the second fluid inlet;

wherein the first and second fluid passages are coaxial with the longitudinal axis of the apparatus, and the first and second fluid outlets are

oriented relative to one another such that they have an angle of incidence of less than 90 degrees;

the second fluid passage includes a throat portion located between the second fluid inlet and the second fluid outlet, the throat portion having a smaller cross sectional area than that of either the second fluid inlet or second fluid outlet; and

the first and second supply channels are substantially parallel to the longitudinal axis of the apparatus.

The second fluid outlet may have a cross sectional area which is between 2.5 and 4 times larger than the cross sectional area of the throat portion.

According to a second aspect of the present invention, there is provided a mist generating apparatus comprising:

a first fluid passage having a first fluid inlet and a first fluid outlet;

a first fluid supply channel having a first end adapted to be connected to a supply of a first fluid and a second end connected to the first fluid inlet;

a second fluid passage having a second fluid inlet and a second fluid outlet; and

a second fluid supply channel having a first end adapted to be connected to a supply of a second fluid and a second end connected to the second fluid inlet;

wherein the first and second fluid passages are coaxial with the longitudinal axis of the apparatus, and the first and second fluid outlets are oriented relative to one another such that they have an angle of incidence of less than 90 degrees;

the second fluid passage includes a throat portion located between the second fluid inlet and the second fluid outlet, the throat portion having

a smaller cross sectional area than that of either the second fluid inlet or second fluid outlet; and

the second fluid outlet has a cross sectional area which is between 2.5 and 4 times larger than the cross sectional area of the throat portion.

The cross sectional area of the throat portion may be between 20 and $35mm^2$. The equivalent angle of expansion of the second fluid passage between the throat and the second fluid outlet may be between 5 and 10 degrees. The cross sectional area of the second fluid outlet may be between 4 and 7 times larger than the cross sectional area of the first fluid outlet.

The first and second fluid outlets may be located adjacent one another.

The first fluid passage may be located radially outward from the second fluid passage. The first fluid passage may surround the second fluid passage.

The first fluid passage may include an intermediate portion located between the first fluid inlet and the first fluid outlet, the intermediate portion having a cross sectional area which is larger than that of either the first fluid inlet or the first fluid outlet.

The apparatus may further comprise a base member, wherein the base member contains the first and second fluid supply channels.

The apparatus may further comprise a funnel member and an elongate plug member, wherein the funnel member has a bore and is adapted to coaxially locate upon the base such that the bore communicates with the second fluid supply channel, and wherein the plug member is adapted to

be attached to the base member such that a portion of the plug lies within the bore and the second fluid passage is defined between the funnel and the plug.

The apparatus may further comprise a cover member which encloses the base member, the funnel member and the plug member such that the first fluid passage is defined between an outer surface of the funnel and an inner surface of the cover member. The cover may have a first end adapted to coaxially locate upon the base member and be attached thereto, and a second end having an outlet adapted to communicate with the first and second fluid outlets.

The second end of the cover may include an axially projecting lip portion, the lip portion defining an aperture in communication with the first and second fluid outlets.

The plug member may have a first end which attaches to the base member and a second end which defines the second fluid passage, wherein the second end is concave.

The funnel member may include a radially projecting flange portion, wherein the flange portion is sandwiched between the base member and the cover member to maintain the axial position of the funnel member relative to the base member.

The cover member may be threaded onto the base such that the axial position of the cover member may be adjusted relative to the base.

The plug member may be threaded onto the base such that the axial position of the plug member may be adjusted relative to the base and the funnel.

According to a third aspect of the present invention, there is provided a method of generating a mist in a mist generating apparatus, the method comprising:

passing a first fluid through a first fluid passage having a first fluid inlet and a first fluid outlet;

passing a second fluid through a second fluid passage having a second fluid inlet and a second fluid outlet;

orienting the first and second fluid outlets relative to one another such that the angle of incidence between the two outlets is less than 90 degrees;

accelerating the flow of second fluid through the second fluid passage;

ejecting the first and second fluids from their respective outlets such that a stream of accelerated second fluid issuing from the second fluid outlet imparts a shear force on a stream of first fluid issuing from the first fluid outlet, thereby at least partially atomising the first fluid to create a dispersed droplet flow regime;

creating a turbulent region of the second fluid downstream of the outlets; and

passing the dispersed droplet flow regime through the turbulent region, thereby further atomising the first fluid in the dispersed droplet flow regime.

The method may also comprise the initial steps of:

supplying the first fluid through a first fluid supply channel which is substantially parallel with the longitudinal axis of the apparatus and in fluid communication with the first fluid inlet; and

supplying the second fluid through a second fluid supply channel which is substantially parallel with the longitudinal axis of the apparatus and in fluid communication with the second fluid inlet.

The method of generating a mist may further comprise the step of controlling the momentum ratio between the first and second fluids. The step of controlling the momentum ratio may include controlling the mass flow ratio between the first and second fluids.

The method of generating a mist may further comprise the step of adjusting the initial trajectory of the first fluid stream exiting the first fluid outlet.

According to a fourth aspect of the present invention, there is provided a method of assembling a mist generating apparatus, comprising the steps of:

forming a base member containing first and second fluid supply channels which are substantially parallel to the longitudinal axis of the apparatus;

forming a funnel member containing a bore, and axially and concentrically locating the funnel member on the base member such that the bore communicates with the second fluid supply channel;

forming an elongate plug member, and axially and concentrically attaching the plug member to the base such that a portion of the plug lies within the bore and a second fluid passage is defined between the concentric funnel and plug;

forming a cover member, the cover member having a first end adapted to enclose the funnel and plug and axially and concentrically locate on the base member, and a second end having an outlet; and

attaching the cover member to the base member such that a first fluid passage is defined between an external surface of the funnel and an internal surface of the cover, and a first fluid outlet of the first fluid passage and the second fluid outlet communicate with the outlet of the cover.

The step of forming the funnel may include forming a flange portion projecting radially therefrom, wherein the step of attaching the cover member to the base includes sandwiching the flange portion of the funnel between the cover member and the base.

The step of attaching the cover member to the base may include threading the cover member onto the base such that the axial position of the cover may be adjusted relative to the base.

The step of attaching the plug member to the base may include threading the plug member onto the base such that the axial position of the plug may be adjusted relative to the base and the funnel.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 shows a longitudinal section view through a base of a mist-generating apparatus;

Figure 2 shows a longitudinal section view through a funnel of a mist-generating apparatus;

Figure 3 shows a longitudinal section view through a plug of a mist-generating apparatus;

Figure 4 shows a longitudinal section view through a cover of a mist-generating apparatus;

Figure 5 shows a longitudinal section view through a mist-generating apparatus formed when the components of Figures 1-4 are assembled;

Figure 6 is an end view of the apparatus shown in Figure 5;

Figure 7 is a detail view of the area marked "VII" in Figure 5;

Figure 8a is a schematic sectional view of the operation of the apparatus shown in Figure 5;

Figure 8b is a schematic view of the geometry of the second fluid passage of the apparatus shown in Figure 5;

Figure 9 is a longitudinal section view of an alternative embodiment of the mist-generating apparatus; and

Figure 10 is a detail view of the area marked "X" in Figure 9.

Figure 1 is a longitudinal section view through a base 12 forming part of a mist-generating apparatus in accordance with the present invention. The base 12 is generally circular and has a rear face 14, a front face 16 and first and second fluid inlet passages 18,20 adapted to receive the first and second fluids from their respective sources (not shown). Each of the fluid inlet passages 18,20 is substantially parallel with the longitudinal axis L of the apparatus. Each fluid inlet passage 18,20 has an internal thread adapted to receive the external thread of respective fluid supply pipes (not shown). Extending longitudinally through the centre of the base 12 is a bore 17. The bore 17 has a generally triangular-shaped recess 19 opening on the rear face 14 of the base 12. The base 12 includes a radially extending flange portion 15 and an axially projecting annular projection 22 which projects forwards from the front face 16. A plurality of circumferentially spaced apertures 21 extend longitudinally through the flange portion 15. The annular projection 22 has an inner surface 24 and

an outer surface 26. The outer surface 26 contains a groove 27 in which an O-ring seal 28 is located.

Figure 2 shows a projecting member, or funnel, 30 which also forms part of the mist-generating apparatus. The funnel 30 is preferably formed as a single piece and comprises a radially extending flange portion 32 and an axially projecting body portion 34. The body portion 34 has an outer surface 37. An annular lip portion 31 extends rearwards from the flange portion 32 and defines an outer surface 33. The outer surface 33 contains a groove 35 in which an O-ring seal 36 is located. The flange portion 32 is annular and extends around the entire circumference of the projecting member 30. Defined within the flange portion 32 are a first fluid passage 38 and an inspection port 39.

The funnel 30 has a first end 41 and a second end 42 and a bore 46 extending longitudinally through the funnel 30 from the first end 41 to the second end 42. The bore 46 has an inlet 47 at the first end 41, an outlet 48 at the second end 42, and a throat portion 49 intermediate the inlet 47 and outlet 48. At the inlet 47 the bore 46 has a diameter D1, at the throat portion 49 the diameter of the bore 46 is D2, and at the outlet 48 the diameter of the bore is D3. The diameter D1 at the inlet 47 is greater than the diameter D2 or D3, whilst the diameter D2 at the throat portion 49 is less than the diameters D1 and D3. As a result, the bore 46 narrows from its widest point at the inlet 47 to a narrow diameter at the throat portion 49 before widening again until it reaches the outlet 48.

Figure 3 shows a plug 50 forming a further part of the mist-generating apparatus. The plug 50 is an elongate member having a first end 51 and a second end 52. The plug 50 has a first generally cylindrical portion 53 and a second conical portion 55 extending from, and preferably integrally

formed with, the cylindrical portion 53. Part of the cylindrical portion 53 adjacent the first end 51 is provided with an external thread 54. The conical portion 55 is in the shape of an inverted cone, with the narrowest point of the cone adjacent the cylindrical portion 53 and the widest point of the cone at the second end 52 of the plug 50. The conical portion 55 has a smallest diameter D4 adjacent the cylindrical portion 53 and a largest diameter D5 at the second end 52 of the plug 50. The cylindrical portion 53 has first and second grooves 56,58 longitudinally spaced from one another and extending around the circumference of the cylindrical portion 53. The first groove 56 is a thread relief groove co-operating with the external thread 54. Also formed part way along the cylindrical portion 53 is a radially projecting lip 60, which defines an abutment surface 62 facing towards the first end 51 of the plug 50. The second groove 58 holds an O-ring seal 57. A further groove 59 is provided in the cylindrical portion 53 of the plug 50 adjacent the first end 51.

The second end 52 of the plug 50, which is also the widest part of the conical portion 55, is concave. Thus, a dish-shaped cavity 64 is formed in the second end 52 of the plug 50. The second end 52 of the plug 50 also includes a pair of locating holes 61.

Figure 4 shows a cover 70 forming part of the mist-generating apparatus. The cover 70 is generally dome-shaped, having a first end 72 of larger diameter than a second end 74. Projecting axially from the second end 74 of the cover 70 is an annular lip 76. The lip 76 has an internal surface 78 of substantially constant diameter. The cover 70 has a first section adjacent the first end 72 which has a first inner surface 73 of substantially constant diameter. Located in the first end 72 of the cover 70 at circumferentially spaced intervals are a plurality of axially extending threaded holes 88. A second section of the cover 70 extending between

the first section and the lip 76 has a second inner surface 75. The portion of the second section adjoining the first section has a smaller diameter than that of the first section, such that a rearward facing abutment 71 is defined between the first and second sections of the cover 70. The diameter of the second section reduces in the direction of the second end 74. In other words, the second inner surface 75 tapers inwardly from the abutment 71 until it reaches the internal surface 78 of the lip 76. Thus, the second inner surface 75 has an inwardly curving profile as it progresses towards the second end 74.

The manner in which the mist-generating apparatus, generally designated 100, is assembled will now be described with particular reference to Figures 5 and 6. Firstly, each of the components shown in Figures 1-4 is formed from a suitable material, which is preferably stainless steel. In the first step of assembling the apparatus 100, the funnel 30 is axially inserted onto the base 12 so that the base 12 and funnel 30 are concentric about the longitudinal axis L, with the outer surface 33 of the funnel lip 31 being guided by the inner surface 24 of the annular projection 22, until the rear face of the flange portion 32 abuts the surface of the annular projection 22. The O-ring seal 36 located in the groove 35 on the outer surface 33 ensures a sealing fit between the two components. When the base 12 and funnel 30 are correctly positioned, the first fluid inlet passage 18 of the base 12 and first fluid passage 38 of the funnel are aligned and capable of fluid communication with one another. Furthermore, the inlet 47 of the funnel bore 46 and the second fluid inlet passage 20 of the base 12 are now in fluid communication with one another as well. Once the base 12 and funnel 30 have been correctly oriented with respect to one another, a temporary locking ring (not shown) is secured over the flange portion 32 of the funnel 30 such that the base 12 and funnel 30 are locked together.

Once the base 12 and funnel 30 are temporarily locked together, the plug 50 can be introduced, firstly via the bore 46 of the funnel 30 and then the bore 17 of the base 12. As best seen in Figure 6, a locking nut 102 is inserted into the recess 19. As the plug 50 is inserted through the bores 46,17 it is rotated by a suitable tool (not shown) which locates in the locating holes 61. As the plug 50 is rotated the threaded surface 54 of the plug 50 marries with the internal thread of the locking nut 102. The outer faces of the nut 102 contact the inner surfaces of the triangular recess 19 such that the recess 19 prevents the nut 102 from rotating as the first end 51 and threaded surface 54 of the plug 50 are threaded through. The lip 60 of the plug 50 has a larger diameter than the bore 17. Consequently, once the abutment surface 62 of the lip 60 comes into contact with the base 12, the plug 50 cannot be threaded any further through the nut 102. At this point, a washer 104 and circlip 106 are fitted to the first end 51 of the plug 50 so that the nut 102 cannot work itself loose. The circlip 106 locates in the groove 59 provided at the first end 51 of the plug 50. The O-ring seal 57 located in the cylindrical portion 53 of the plug 50 ensures a sealing fit between the plug 50 and the bore 17.

As can be seen in Figure 5, once the plug 50 is axially and concentrically located in the bore 17, the conical portion 55 of the plug 50 lies between the throat portion 49 and outlet 48 of the bore 46 in the funnel 30. Consequently, the inner surface of the bore 46 and outer surface of the plug 50 now define a second fluid passage 90. The inlet 47 of the funnel bore 46 acts as the inlet of the second fluid passage 90, with the second fluid passage having a throat portion 92 adjacent the throat 49 of the bore 46, and an outlet 94 adjacent the respective second ends 42,52 of the funnel 30 and plug 50. As a result of the previously mentioned variations in the diameter of the bore 46 and the outward taper of the conical portion 55 of the plug 50, the second fluid passage 90 has a convergent-divergent

internal geometry. In other words, the cross-sectional area of the throat portion 92 of the passage 90 is considerably smaller than that of the inlet 47 and the outlet 94. The cross sectional area of the passage 90 at the outlet 94 is greater than that at the throat portion 92, but less than that at the inlet 47.

Once the plug 50 has been fixed to the base 12, the inspection port 39 can be used to measure the axial distance between the top surface of the annular projection 22 and the remote second ends 42,52 of the funnel 30 and plug 50. This ensures that the base 12, funnel 30 and plug 50 are all correctly positioned relative to one another. At the same time, measuring instruments can be used to check the gap between the funnel 30 and plug 50 which forms the second fluid passage 90.

Once the measurement and positioning checks have been completed, the temporary locking ring can be removed and replaced with the cover 70. The cover 70 is axially placed on the base 12 such that the abutment 71 contacts the flange portion 32 of the funnel 30, and the cover is then concentric with the other components and the axis L. This sandwiches the flange portion 32 between the base 12 and cover 70, holding the base 12 and funnel 30 against one another. At the same time, the O-ring seal 28 ensures a sealing fit between the base 12 and cover 70. The cover 70 is aligned with the base 12 so that the threaded apertures 88 align with the apertures 21 in the base 12. A plurality of fixing screws 108 are then tightened into the threaded apertures 88 via the apertures 21 in the base 12. Once the screws 108 are fully tightened the heads of the screws 108 are at least flush with the rear face 14. A number of blind mounting holes 110 with internal threads are also provided on the rear face 14 of the base 12 for attaching the apparatus to a suitable mounting skid or the like.

As seen best in Figure 5, once the cover 70 is successfully fitted, the second inner surface 75 of the cover 70 and the outer surface 37 of the funnel 30 define a first fluid passage 80 having an inlet 82 and an outlet 84. The inlet 82 is in fluid communication with the first fluid inlet 18 and first fluid passage 38. Due to the contours of the second inner surface 75 and outer surface 37 the first fluid passage 80 has a divergent-convergent internal geometry. In other words, the cross sectional area of a portion of the first fluid passage 80 intermediate the inlet 82 and outlet 84 is greater than the cross sectional area at either the inlet 82 or outlet 84. The progressive reduction in the cross sectional area of the first fluid passage 80 following the intermediate portion creates a smooth curvature to the inner surface 75.

Figure 7 shows a detail view of the respective outlets 84,94 of the first and second fluid passages 80,90. Once the various components are correctly assembled, the outlet 94 of the second fluid passage 90 is defined between the second ends 52,42 of the plug 50 and funnel 30. The outlet 84 of the first fluid passage 80 is defined between the second end 42 of the funnel 30 and the inner surface 78 of the lip 76.

The way in which a mist is generated by the apparatus will now be described with particular reference to Figures 8a and 8b. Initially, supplies of first and second fluids are connected to the respective first and second fluid inlets 18,20. The first fluid, also known as the working fluid, is preferably water. The second fluid, also known as the transport fluid, is preferably a gas such as compressed air, nitrogen or helium, for example. The first fluid passes through the first fluid passage 80 which narrows considerably in the direction of its outlet 84. As a result of this narrow gap at the outlet 84, the first fluid ejects out of the outlet 84 as a thin annulus of first fluid, initially following a path represented in Figure 8a by the dotted

line 120. The initial path of the first fluid 120 is substantially parallel to the inner surface 78 of the lip 76.

Due to the reduction and subsequent increase in the cross sectional area of the second fluid passage 90 between its inlet 47, throat 92 and outlet 94 the second fluid entering the inlet 47 is accelerated to a high, possibly even supersonic, velocity as it exits the outlet 94. The angle of the second fluid passage 90 is such that the accelerated second fluid stream, whose initial trajectory is shown as dotted line 122 in Figure 8a, exits the outlet 94 and interacts with the annulus of first fluid issuing from the outlet 84. The angle α between the first fluid and second fluid streams 120,122 is relatively shallow as it is less than 90°.

Figure 8a also illustrates an equivalent angle of expansion γ for the second passage 90 as it expands between the throat 92 and the outlet 94. Figure 8b shows schematically how this equivalent angle of expansion γ for the second fluid passage can be calculated when the cross sectional areas of the throat and outlet, and the equivalent path distance between the throat and outlet are known. E1 is the radius of a circle having the same cross sectional area as the throat of the second fluid passage. E2 is the radius of a circle having the same cross sectional area as the outlet of the second fluid passage. The distance d is the equivalent path distance between the throat and the outlet. An angle β is calculated by drawing a line drawn through the top of E2 and E1 which intersects a continuation of the equivalent distance line d. This angle β can either be measured from a scale drawing or else calculated from trigonometry using the radii E1,E2 and the distance d. The equivalent angle of expansion γ for the second fluid passage can then be calculated by multiplying the angle β by a factor of two, where $\gamma=2\beta$.

For optimum performance of the apparatus, it has been found that the cross sectional area of the throat portion 92 of the second fluid passage 90 should preferably be between 20mm^2 and 35mm^2 and that the cross sectional area at the outlet 94 of the second fluid passage should preferably be between 2.5 and 4 times larger than that of the throat portion 92. This increase in cross sectional area between the throat portion 92 and outlet 94 creates a preferred equivalent included angle of expansion γ for the second fluid passage 90 of between 5 and 10 degrees. Furthermore, it has also been found that the cross sectional area of the second fluid passage outlet 94 should be between 4 and 7 times larger than the cross sectional area of the first fluid passage outlet 84.

The stream of second fluid 122 coming into contact with the stream of first fluid 120 causes shear stripping of droplets from the annulus of first fluid 120 due to Kelvin-Helmholtz and Raleigh-Taylor instabilities on the first fluid surface. These instabilities cause ligaments of the first fluid to break off from the annulus and form a dispersed droplet flow regime of the first and second fluids. As the droplets are torn from the first fluid stream 120 they are accelerated by the second fluid, causing further shear break-up. The second fluid creates a turbulent region 124 as it moves away from the apparatus. This turbulent region 124 applies acceleration and deceleration forces on the droplets, leading to a further atomisation of the droplets being carried by the second fluid. This atomisation mechanism can be controlled by, amongst other things, controlling the momentum flux ratio between the first and second fluids.

As most clearly shown in Figure 8, the first and second fluid streams 120,122 issuing from their respective outlets 94,84 are angled relative to one another at an angle ά. The angle ά between the streams 120,122 causes the second fluid stream 122 to impinge on the annulus forming the

first fluid stream 120. This improves atomisation as the second fluid stream 122 disrupts the first fluid stream 120. The inner surface 78 of the lip 76 ensures that larger droplets torn from the first fluid stream 120 that could be projected away from the longitudinal axis L of the apparatus by the second fluid stream 122 are prevented from doing so. Furthermore, droplets held against the inner surface 78 of the lip 76 are more easily atomised as they are subject to the both the force of the second fluid and the friction forces from the inner surface 78.

Figures 9 and 10 show views of an alternative embodiment of a mist-generating apparatus in accordance with the present invention. The alternative embodiment of the apparatus, generally designated 100', shares a number of components with the previously described embodiment and generally operates in the same manner. However, the alternative embodiment does also have a number of differences from the first embodiment. Most noticeably, the second end 74' of the cover 70' does not have a protruding lip. The second end 74' is therefore adjacent the first and second fluid outlets 84',94'. The funnel 30' of this alternative embodiment does not have a radially projecting flange portion which is sandwiched between the cover 70' and the base 12'. Instead, the funnel 30' is secured directly to the base 12' by a number of fixing screws (not shown). Additionally, instead of being secured together by screw fixings the cover 70' has an internal thread on its inner surface 73' which cooperates with an external thread on the outer surface 26' of the base 12'. The cover 70' can therefore be threaded onto the base 12', and turning the cover 70' relative to the base 12' will adjust the axial distance between the cover 70' and both the base 12' and the funnel 30' directly secured to the base 12'.

As seen best in Figure 10, the first fluid outlet 84' has been adapted in several ways in the alternative embodiment. Firstly, the width of the gap between the second ends 42',74' of the funnel 30' and cover 70' which forms the first fluid outlet 84' has been increased. This provides a different flow characteristic (e.g. velocity) for the same flow rate condition. Secondly, as the axial distance between the cover 70' and the funnel 30' can be adjusted in this embodiment, the angle of projection of the first fluid can also be adjusted. Adjusting the axial position of the cover 70' relative to the base 12' and funnel 30' adjusts the relative axial positions of the second end 74' of the cover 70' and the second end 42' of the funnel 30', both of which define the first fluid outlet 84'. The adjustment of these components therefore also adjusts the gap size of the first fluid outlet 84' and initial path 120' of the first fluid stream as it exits through the first fluid outlet 84'. As a result, the more the cover 70' is screwed onto the base 12' the more the initial path of the first fluid stream 120' issuing from the outlet 84' will diverge from the longitudinal axis L' of the apparatus 100'. In the first embodiment, the angle of projection was substantially parallel with the longitudinal axis of the apparatus. The variation in the angle of projection also reduces the angle of incidence α' between the first and second fluid streams 120',122' issuing from their respective outlets 84',94'.

The plug 50' in the alternative embodiment has a longer threaded surface 54' and no lip portion limiting its axial position relative to the base 12'. The bore 17' in the base 12' has an internal thread which engages the threaded surface 54' of the plug 50'. As a result, the axial position of the plug 50' relative to the base 12' and the other main components can be adjusted depending upon the amount that the plug 50' is screwed into the base 12'. This also allows the width of the second fluid passage 90' and outlet 94' to be adjusted, as the position of the plug 50' can be adjusted relative to the funnel 30'. Consequently, the adjustment of the plug 50'

also adjusts the area ratio between the throat and outlet of the second fluid passage, as well as the equivalent angle of expansion of the second fluid passage. Once the desired position of the plug 50' has been obtained, a lock nut 102' is fitted over the first end 51' of the plug 50' protruding from the rear face 14' of the base 12'.

The present invention provides a mist generating apparatus which has a single supply channel for each of the first and second fluids. The supply channels are substantially parallel with the longitudinal axis of the apparatus, thereby reducing the supply pressures needed to supply the fluids. Having single supply channels for each fluid which are substantially parallel to the longitudinal axis of the apparatus allows the apparatus and supply lines to be more easily manufactured and installed on a mounting skid or the like, in comparison to mist generators which have one or more supply channels which enter the apparatus perpendicular to the longitudinal axis.

The geometry of the fluid passages and their respective outlets also provides the present invention with improved performance compared with existing mist generators. The area ratio between the throat and outlet of the second fluid passage and the angle of the initial trajectories of the first and second fluids from their respective outlets ensure that the second fluid exits the apparatus and atomises the first fluid in an improved manner compared to earlier proposals. The area ratio between the first and second fluid outlets, and the relatively shallow angle of incidence between the two streams of the fluid exiting the outlets also improve atomisation performance in the present invention. Using the second fluid stream to create a turbulent region outside the apparatus ensures further atomisation of the first fluid, again improving the atomisation performance of the present invention.

The method in which the apparatus is assembled also has benefits over previous proposals. The base, funnel, plug and cover are all assembled concentrically in such a way that the gaps defining the fluid passages and outlets between the components are consistent along the length and around the circumference of the apparatus. Furthermore, as each of the funnel, plug and cover are attached or mounted to the base plate, the components have a common reference point. This ensures that tolerance errors are minimised instead of being multiplied, as is often the case in prior art assemblies where the components are assembled together without a common reference.

Where present, the axially projecting lip of the cover member prevents damage to the funnel and plug if the apparatus is dropped. The relative positions of these components, and hence the geometry of the first and second passages, is therefore protected.

One or more of the fixing screws used in the assembly of the apparatus may be replaced with an alternative mechanical fixing means where appropriate. One or more of the mechanical fixing means may be a tamper proof or tamper evident fixing means in order to either prevent or highlight disassembly of the apparatus following installation.

Instead of using a threaded arrangement as in the alternative embodiment, the adjustment of the axial position of the cover relative to the base may alternatively be achieved by inserting shims between the two components and then tightening the two components together in a manner similar to that of the first embodiment.

These and other modifications and improvements may be incorporated without departing from the scope of the invention.

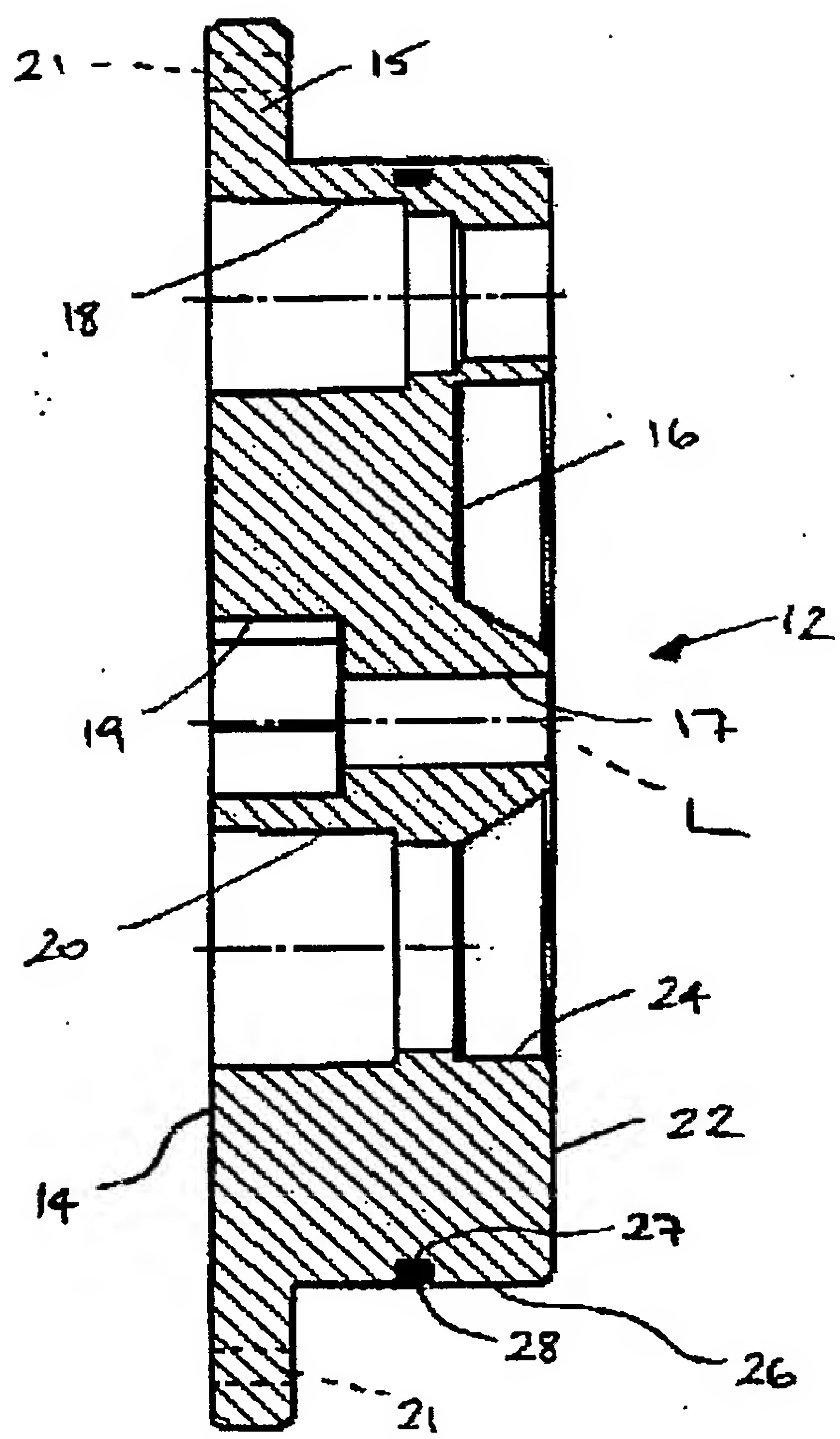

Figure 1

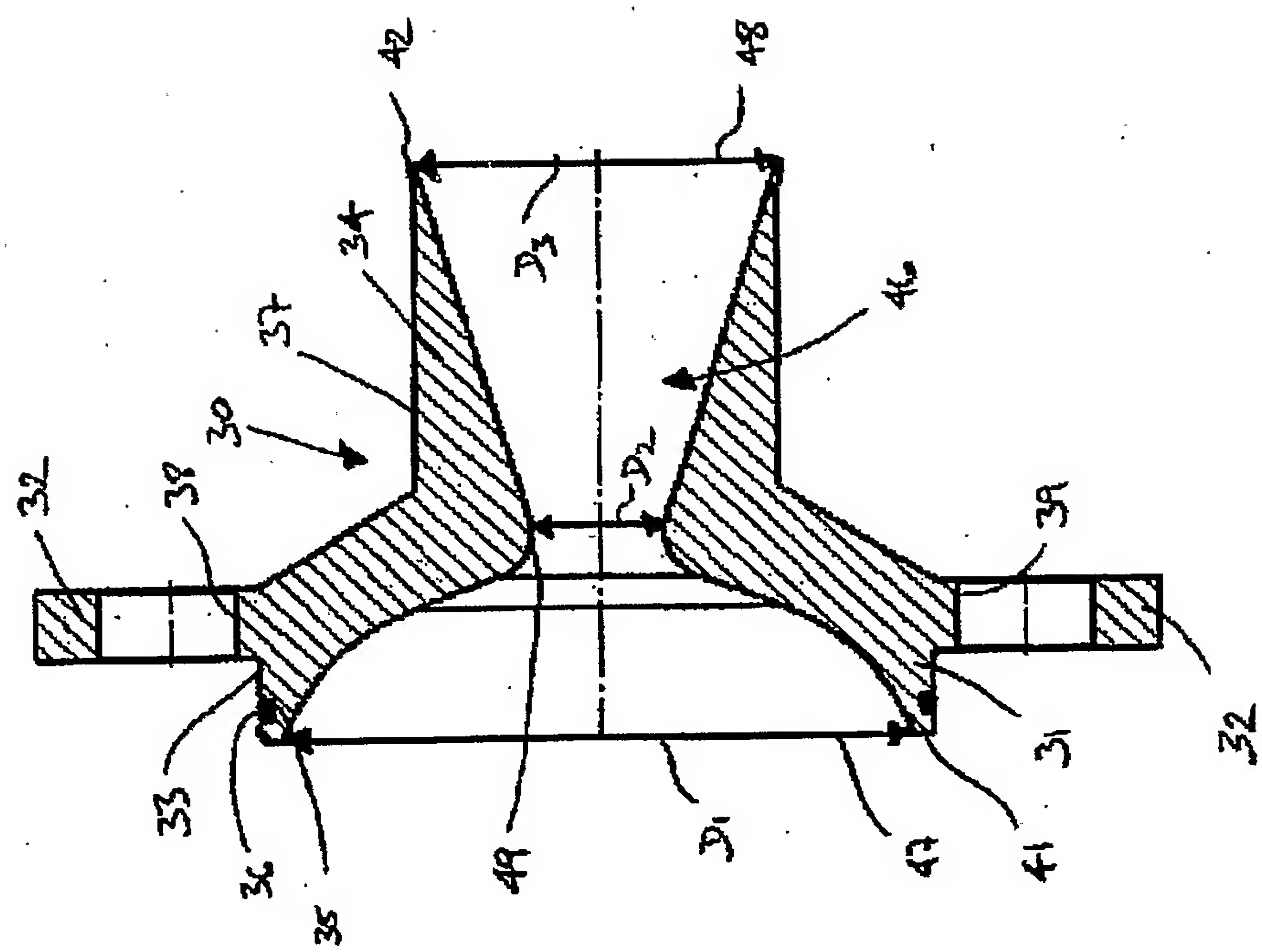

Figure 2

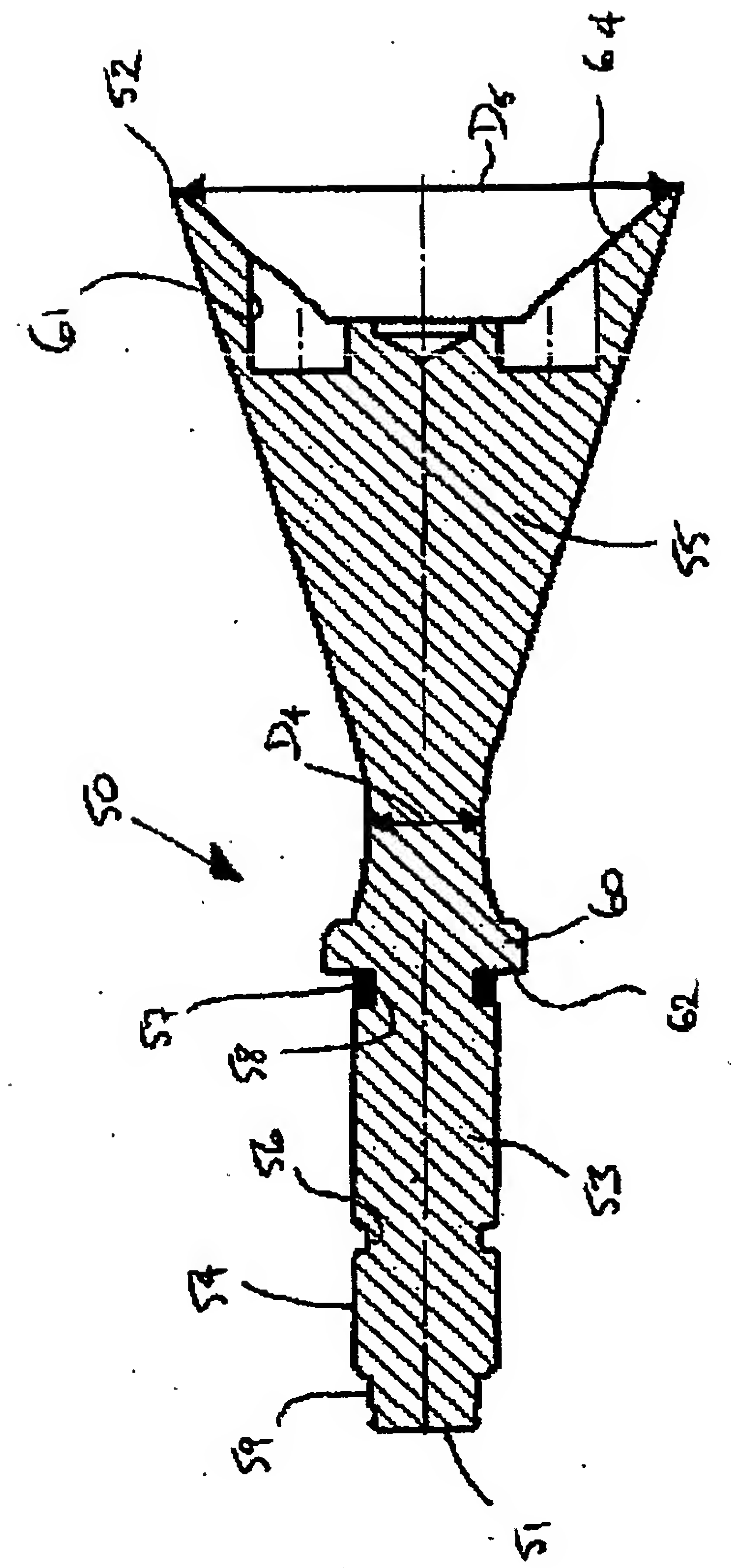

Figure 3

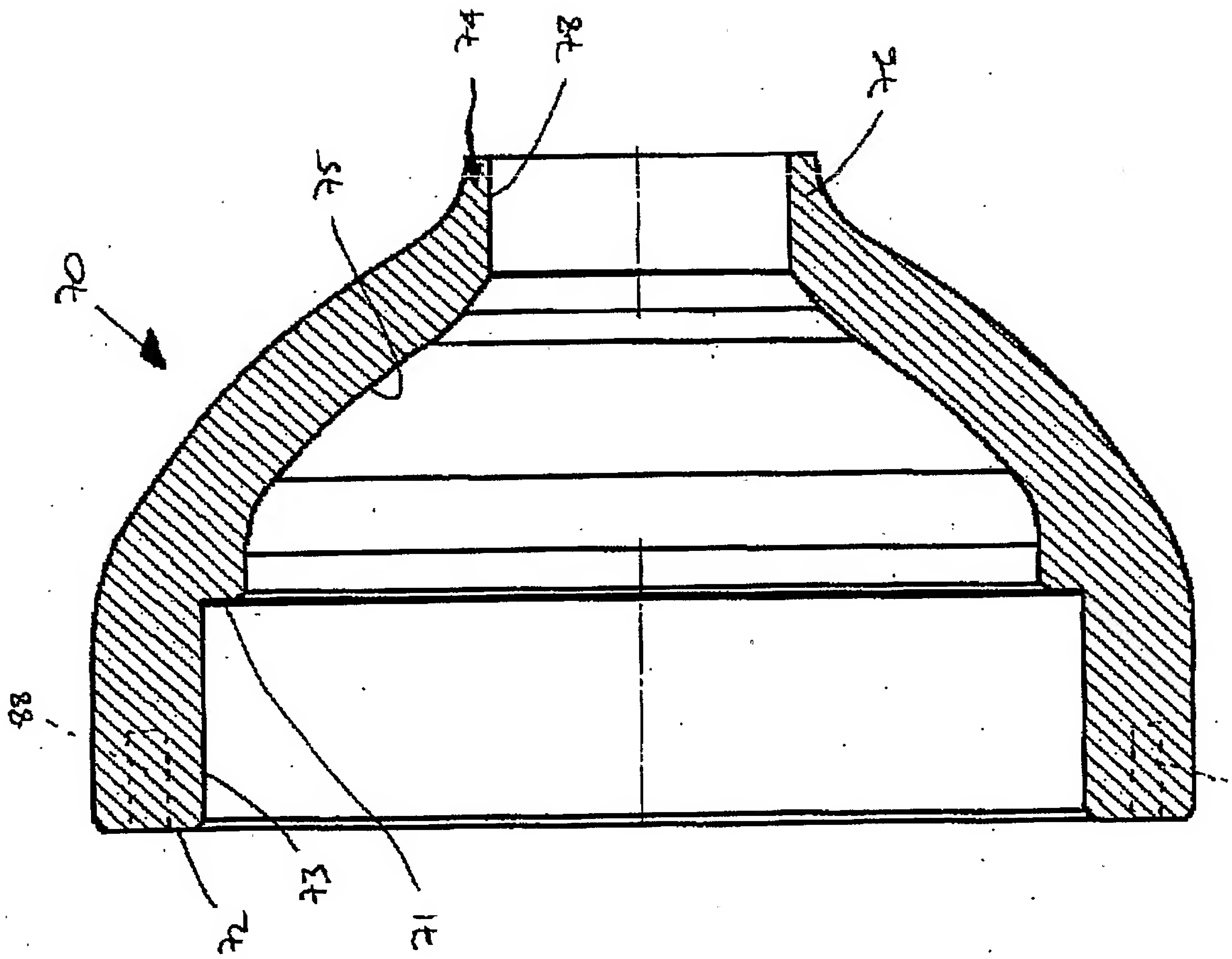

Figure 4

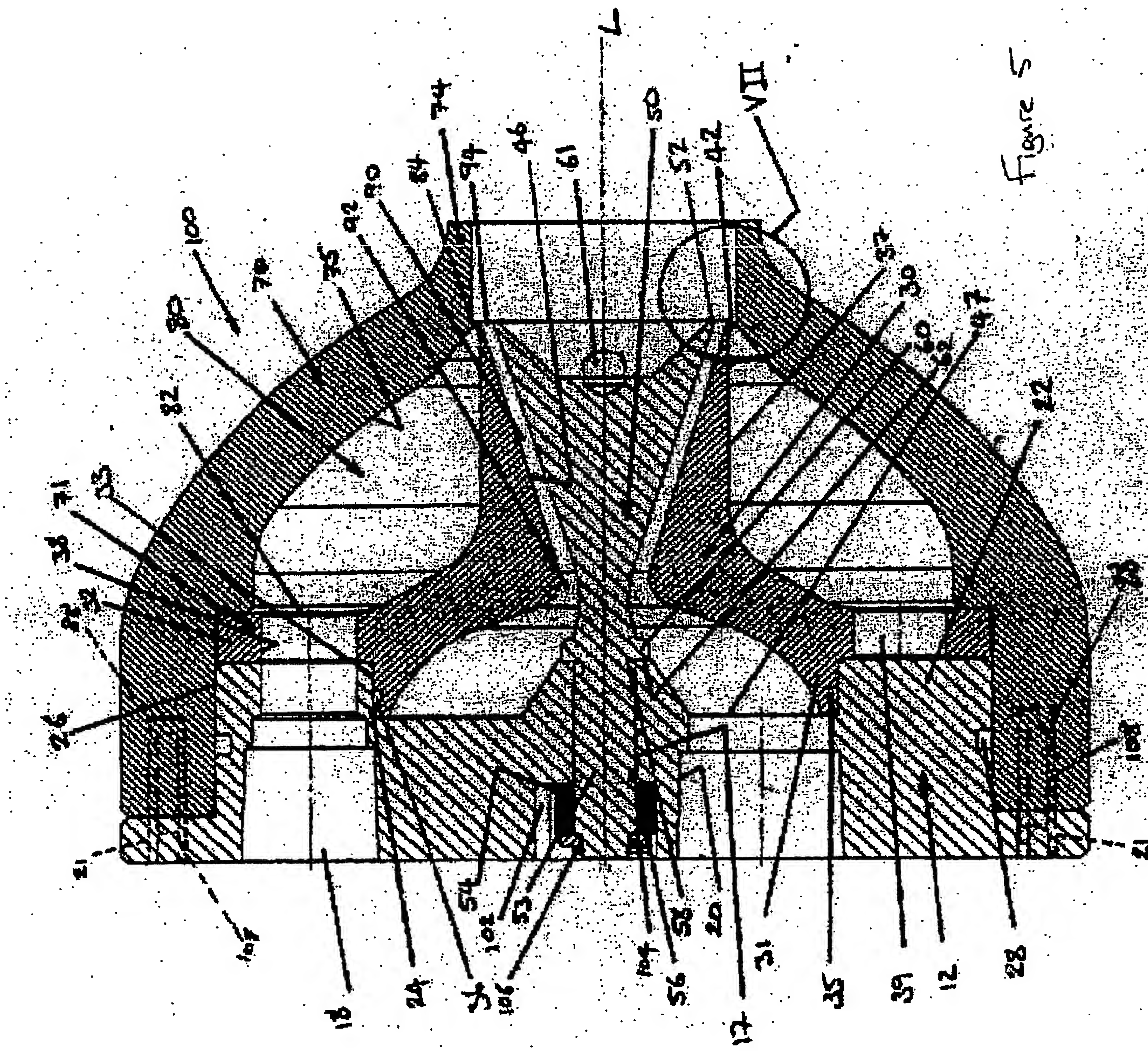

Figure 5

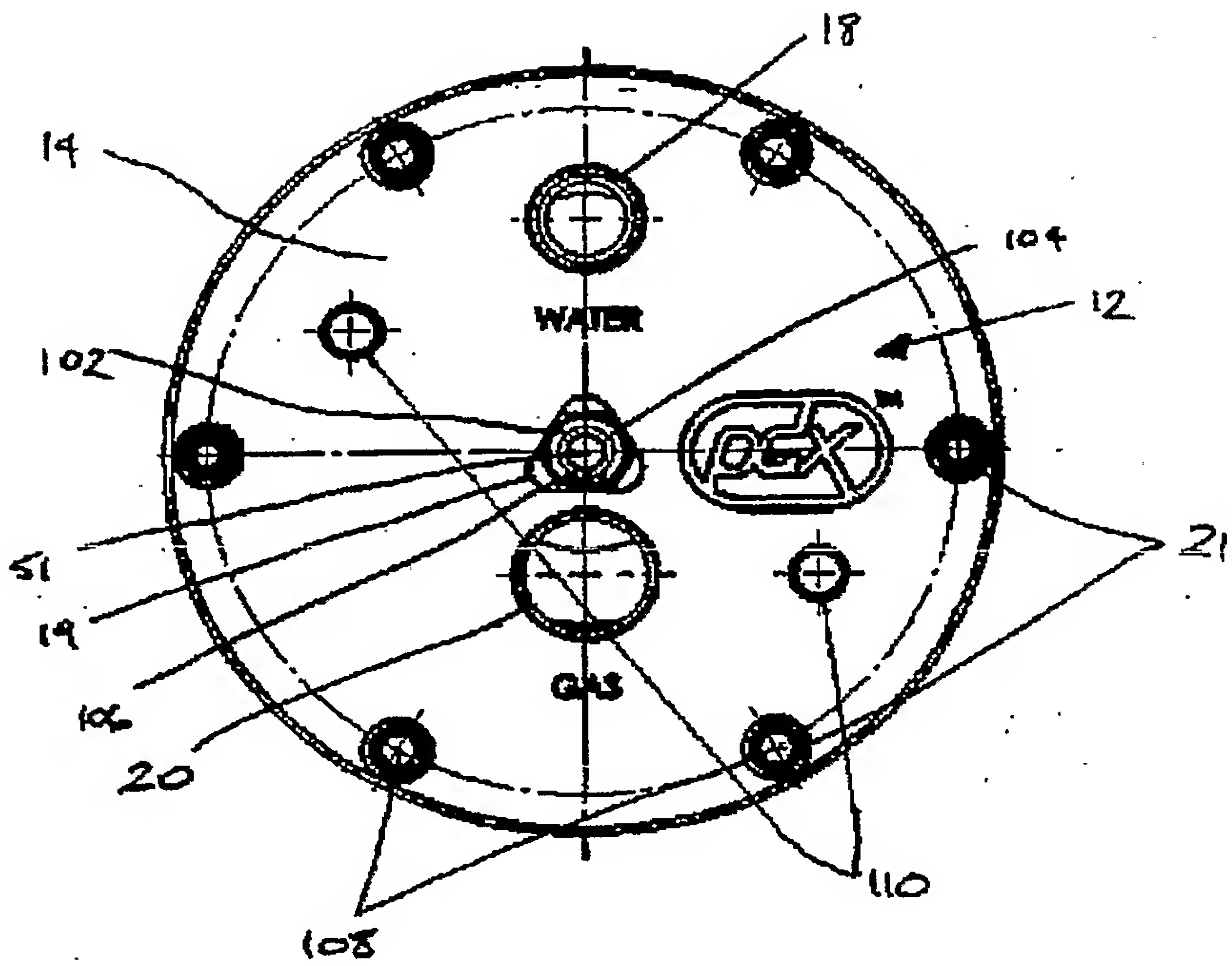

Figure 6

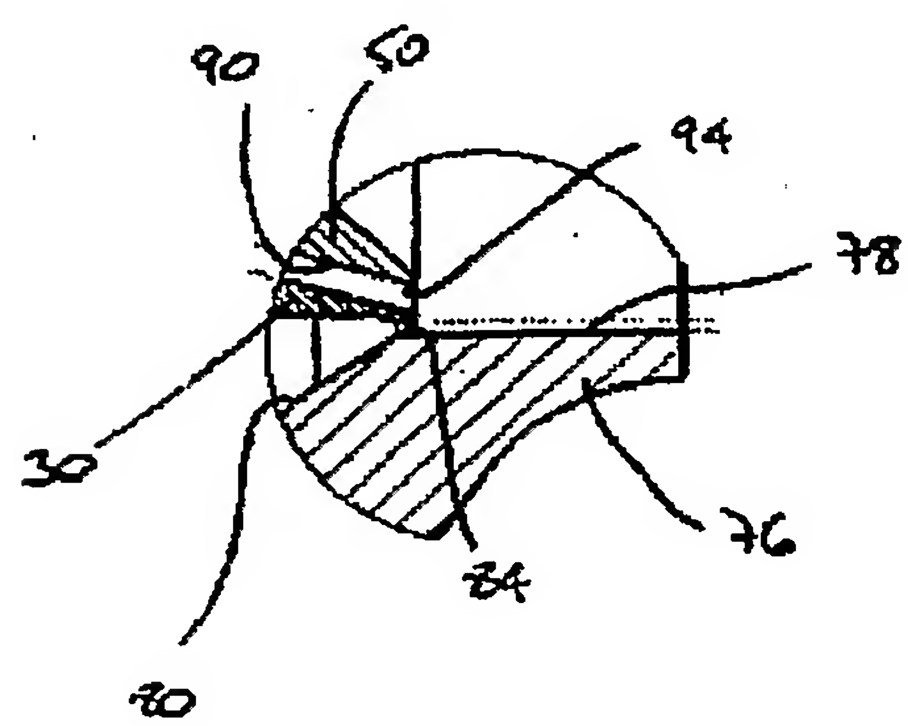

Figure 7

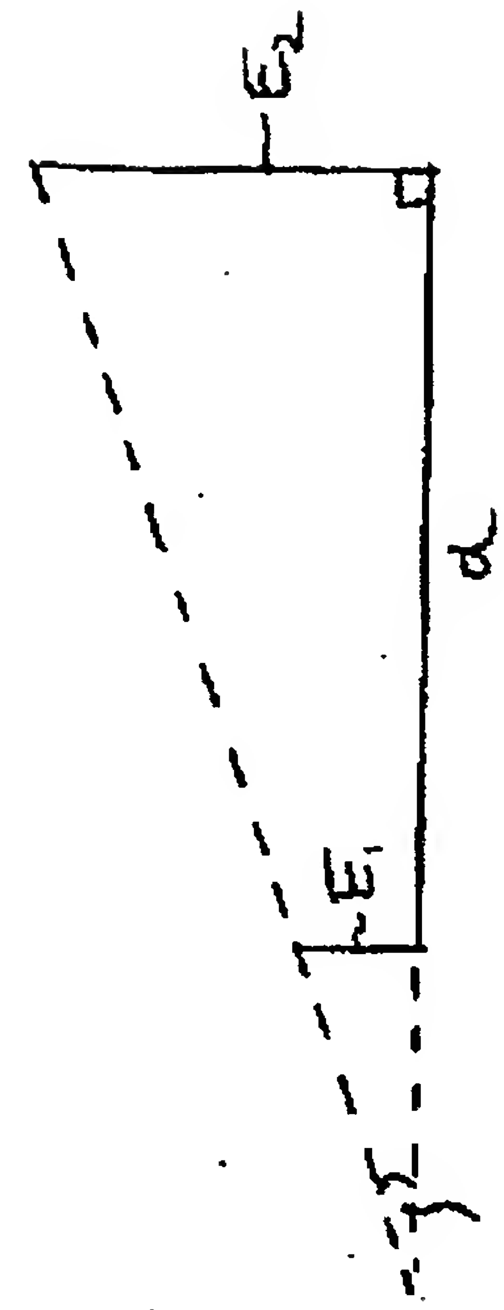

Figure 8b

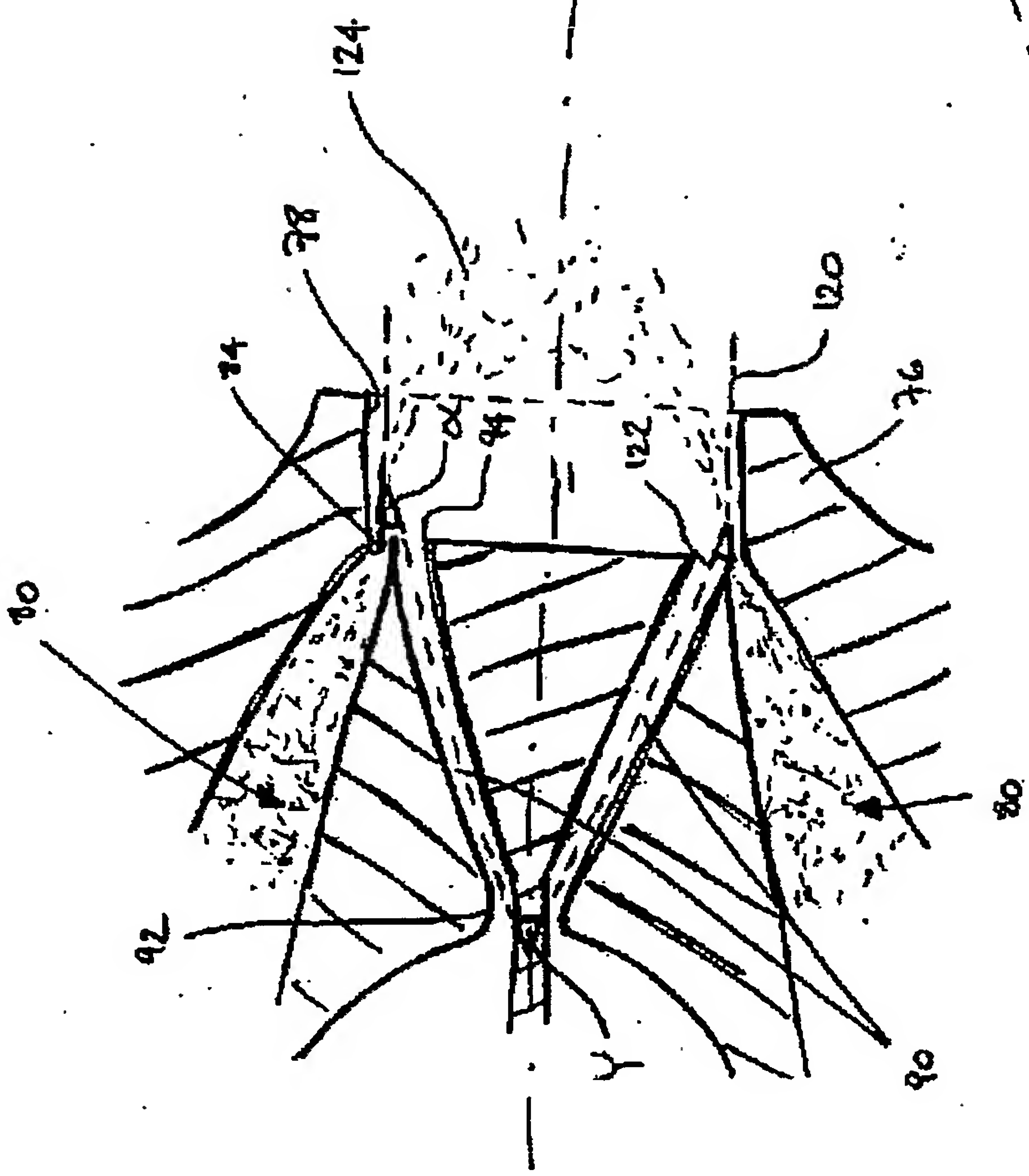

Figure 8a

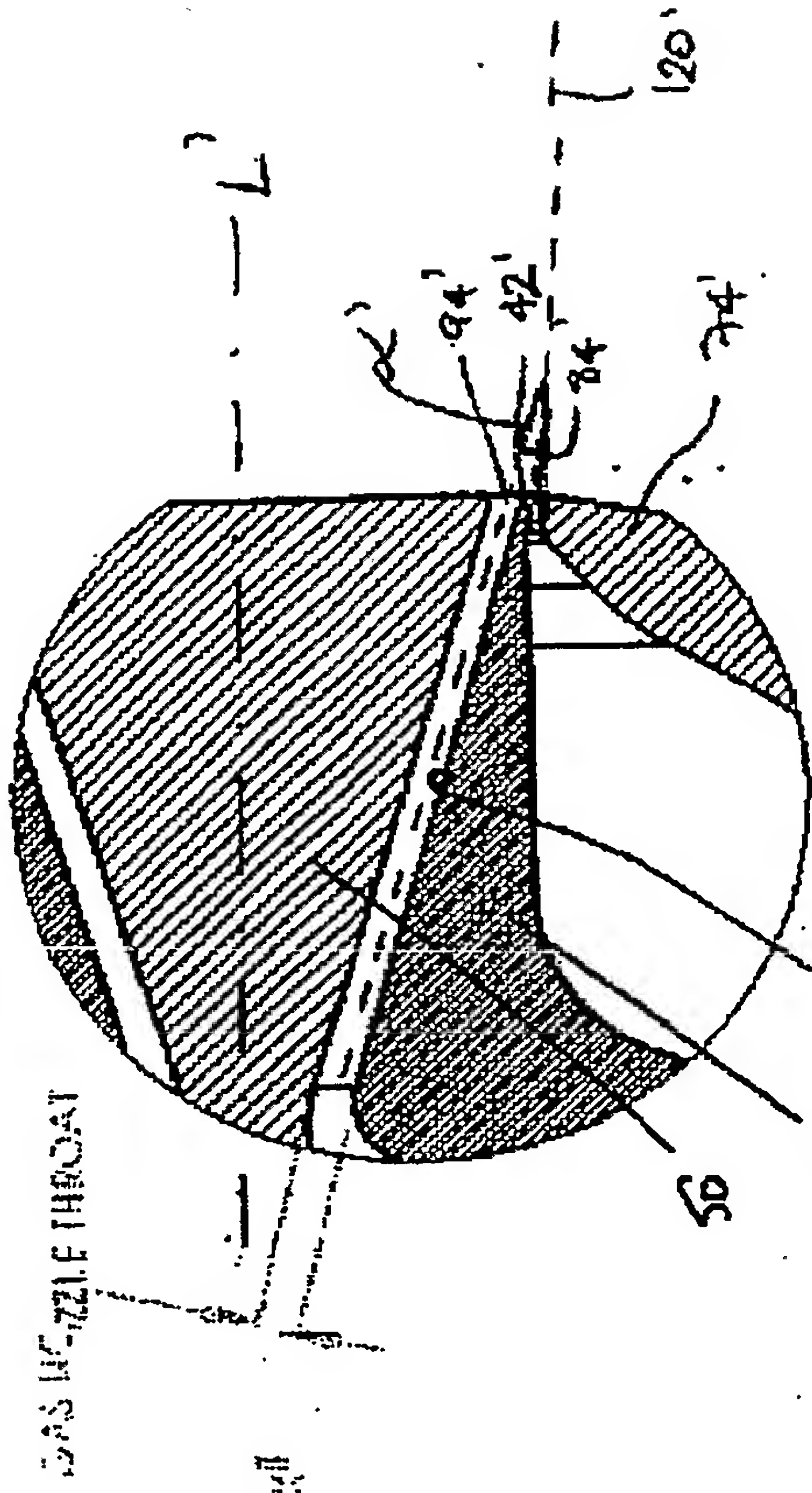

Figure 10

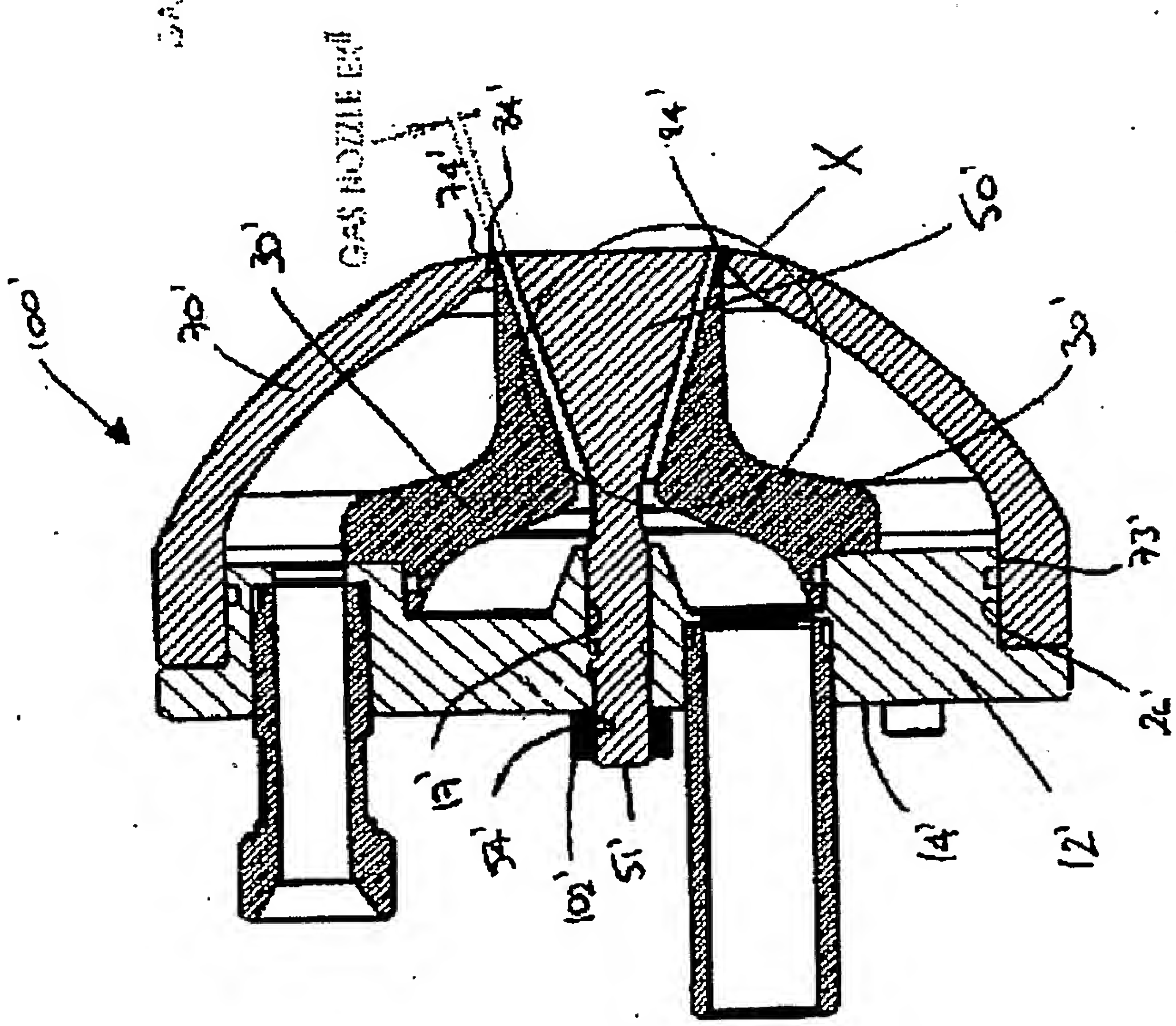

Figure 9